Economic Analysis
Research Paper Series

Real Gross Domestic Income, Relative Prices and Economic Performance Across the OECD

by Ryan Macdonald

No. 059

Statistics Canada Statistique Canada

Canada

Real Gross Domestic Income, Relative Prices and Economic Performance Across the OECD

by Ryan Macdonald

11F0027M No. 059
ISSN 1703-0404
ISBN 978-1-100-14542-6

Statistics Canada
Economic Analysis Division
R.H. Coats Building, 18th floor, 100 Tunney's Pasture Driveway
Ottawa, Ontario K1A 0T6

How to obtain more information:
National inquiries line: 1-800-263-1136
E-Mail inquiries: infostats@statcan.gc.ca

January 2010

Published by authority of the Minister responsible for Statistics Canada

La version française de cette publication est disponible (n° 11F0027M au catalogue, n° 059).

Note of appreciation:

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued co-operation and goodwill.

Standards of service to the public

Statistics Canada is committed to serving its clients in a prompt, reliable and courteous manner. To this end, Statistics Canada has developed standards of service that its employees observe. To obtain a copy of these service standards, please contact Statistics Canada toll-free at 1-800-263-1136. The service standards are also published on www.statcan.gc.ca under "About us" > "Providing services to Canadians."

Economic Analysis Research Paper Series

The Economic Analysis Research Paper Series provides for the circulation of research conducted by the staff of National Accounts and Analytical Studies, visiting Fellows and academic associates. The research paper series is meant to stimulate discussion on a range of topics including the impact of the New Economy, productivity issues, firm profitability, technology usage, the effect of financing on firm growth, depreciation functions, the use of satellite accounts, savings rates, leasing, firm dynamics, hedonic estimations, diversification patterns, investment patterns, the differences in the performance of small and large, or domestic and multinational firms, and purchasing power parity estimates. Readers of the series are encouraged to contact the authors with comments, criticisms and suggestions.

The primary distribution medium for the papers is the Internet. These papers can be downloaded from the Internet at www.statcan.gc.ca for free.

All papers in the Economic Analysis Series go through institutional and peer review to ensure that they conform to Statistics Canada's mandate as a government statistical agency and adhere to generally accepted standards of good professional practice.

The papers in the series often include results derived from multivariate analysis or other statistical techniques. It should be recognized that the results of these analyses are subject to uncertainty in the reported estimates.

The level of uncertainty will depend on several factors: the nature of the functional form used in the multivariate analysis; the type of econometric technique employed; the appropriateness of the statistical assumptions embedded in the model or technique; the comprehensiveness of the variables included in the analysis; and the accuracy of the data that are utilized. The peer group review process is meant to ensure that the papers in the series have followed accepted standards to minimize problems in each of these areas.

Publications Review Committee
Analytical Studies Branch, Statistics Canada
18th Floor, R.H. Coats Building
Ottawa, Ontario K1A 0T6

Symbols

The following standard symbols are used in Statistics Canada publications:

.	not available for any reference period
..	not available for a specific reference period
...	not applicable
0	true zero or a value rounded to zero
0^s	value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded
^{p}	preliminary
^{r}	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
^{E}	use with caution
F	too unreliable to be published

Table of contents

Abstract

This paper uses Organization for Economic Co-operation and Development (OECD) data to examine changes in labour productivity, real gross domestic product (GDP), real gross domestic income (GDI), economic aggregates and relative economic growth over time. Real GDI combines changes in production (real GDP), with a trading gain derived from relative price changes. The paper considers two sources of trading gains: the terms of trade and the real exchange rate. For OECD countries, the terms of trade is the more important price ratio, making a contribution to real income growth that is, on average, an order of magnitude larger than the real exchange rate.

Over long time periods, the most important source of real income growth is changes in production. Over shorter time horizons, however, the trading gain can make noteworthy contributions. Changes in aggregates, like real private consumption or the relative economic performance of nations, are shown to be particularly dependent on the trading gain during the large swings in resource prices that occurred after 2002.

Executive summary

This paper uses a real income measure referred to as real gross domestic income (GDI), to examine the 2003-to-2007 period, when an unprecedented rise in commodity prices occurred. As a result, changes in the terms of trade occurred throughout the developed world. In resource-rich, resource exporting countries, a rising terms of trade allowed individuals, governments and businesses to turn their production into consumption and investment at an accelerated rate. In resource importing countries, growth in consumption and investment lagged behind production growth.

Real GDI combines changes in production (real gross domestic product [GDP]) with changes in the purchasing power of that production on world markets (a trading gain). Using real GDI breaks the fixed relationship between real income and production that occurs when real GDP is used. Real GDI is interpreted as a measure of purchasing power, or absorption, rather than a measure of production.

By using real GDI, questions are answered about how the rapid increases in resource prices from 2003 to 2007 affected OECD nations, and how that period compares to previous resource cycles.

- Is the 2003-to-2007 period unusual?

  The 2003-to-2007 years are historically unusual because of the breadth of commodities for which prices increased. Across almost all commodities, from energy to lumber to minerals to grains, prices rose. During previous episodes of rapid commodity price change, price increases tended to be more concentrated in a particular area, such as energy prices in the 1970s.

- How did the rapid increase in resource prices effect relative prices?

  The rapid climb in commodity prices increased the prices of commodities (inputs) relative to the price of manufactured goods (outputs). As a result, those countries that export commodities in order to import manufactured goods saw the value of their exports rise, while countries that export manufactured goods in order to import commodities saw the value of their exports fall.

  A numerical estimate of the trade-off between resources and manufactured products is provided by the terms of trade. The terms of trade rose in resource exporting nations, while it declined in resource importing nations.

- What countries benefited the most from the resource boom? What countries benefited the least? Did benefits from the resource boom translate into changes in consumption and investment?

  The biggest beneficiaries of the resource boom were resource exporting, manufacturing importing nations like Norway, Australia, New Zealand and Canada. In these countries, real consumption and real investment grew faster than real GDP as the terms of trade increased, allowing them to turn their stream of production into a larger stream of consumption or investment because the value of their exports had increased. The effect was similar to flying with a tail wind – they moved forward, but at a faster rate than their output growth would imply.

The countries that benefited the least were manufacturing exporting, resource importing nations like Japan, Korea and the United States, where the terms of trade worked against consumers, businesses and governments. As the value of their exports declined, these countries had to send more goods abroad to purchase the inputs to their production processes, thereby reducing the supply of goods for domestic consumption and investment. The effect in these countries was similar to flying into a head wind – they moved forward, but at a slower rate than their output growth would imply.

- What countries 'performed' the best relative to the United States, between 2003 and 2007?

Comparisons of economic performance depend greatly on the metric used between 2003 and 2007. An efficiency measure, like labour productivity for example, shows resource-rich, resource exporting nations like Norway, Australia, New Zealand and Canada falling behind the United States. Moving to a real GDI per capita measure, however, (which includes the effect of the resource boom on purchasing power), shows these four countries gaining ground on the United States.

Answering the question, 'What country performed best between 2003 and 2007?', therefore, requires specificity about whether one is interested in a measure of production efficiency or a measure of purchasing power.

1 Introduction

Economists examine real income differences across countries and over time in an effort to understand differences in living standards. Real GDP is an income measure that assumes all real income change comes from changes in production and labour productivity (a measure of output per hour worked). Both measures are frequently employed for this purpose. New processes, technological breakthroughs, or higher labour and capital inputs lead to increases in real GDP. Technological advances and increases in the capital: labour ratio raise labour productivity. Through examining the production process, (or the real income it generates), real GDP and labour productivity are used as a base for productivity analysis (see for example Hulten 2001), real income analysis (see for example Rodgers 2003), and to model economic aggregates such as consumption.

Relative prices however, also affect real income growth. Depending on how the relative prices of exports and imports change, the volume of goods and services that an economy can purchase may differ from its volume of production. An economy may improve its labour productivity (raising the efficiency with which it produces goods and services), but if it produces goods for export whose prices are falling relative to the imported goods it purchases, that economy may not see much of an increase in its standard of living, as measured by the purchasing power of its income. After 2002, the importance increased greatly of taking these factors into account to understand the outcomes of international income comparisons or changes in economic aggregates, such as consumption or imports.

2003-2007 was a period of global expansion, when emerging nations, particularly China, gained prominence as important economic centres. Prices rose sharply for most commodities, while at the same time, relative prices for many manufactured products fell (Francis 2007). This confluence of events led to the largest relative price shifts experienced by OECD nations since the second oil shock. The 2003-2007 years, therefore, provide a unique period during which the influence of relative price change is conspicuous.

This paper uses a real income measure referred to as real gross domestic income (GDI) to examine the role of relative price changes in real income growth. Using real GDI breaks the fixed relationship between real income and production that occurs when real GDP is used. Real GDI is interpreted as a measure of purchasing power, or absorption, rather than a measure of production. Growth in real GDI captures changes in the volume of goods and services available to a domestic economy and is associated with changes in utility (Kohli 2004).

Moving from real GDP to real GDI involves accounting for relative price changes related to traded products. Two relative prices are considered here: the terms of trade and the real exchange rate. The terms of trade is defined as the ratio of export to import prices, while the real exchange rate is defined as the ratio of traded to non-traded prices.

Data for 29 Organization for Economic Co-operation and Development (OECD) countries are used to examine sources of real income growth to demonstrate the importance of commodity prices (for terms of trade and real exchange rate changes), relative price adjustment (for understanding movements in economic aggregates like consumption), and changes in economic performance over time. This paper focuses on the 2003-2007 period because during these years, rapid increases in commodity prices after 2002 created dramatic changes for relative prices. The historical record is employed to provide a long-term perspective, and to

provide comparisons between the 2003-2007 resource boom with previous resource price cycles.

The remainder of the paper is organized as follows. Section 2 discusses real GDP, labour productivity and real GDI, while Section 3 discusses data and methodology. Section 4 examines labour productivity, real GDI and real GDP across OECD countries during the 2003-to-2007 period, paying particular attention to relative price changes that reflect commodity price cycles. Section 5 looks at how much cross-sectional variation in real aggregates can be explained using real GDI. Section 6 contains a comparison of economic performance relative to the United States, between 2003 and 2007. Section 7 examines how real GDP and labour productivity compared to real GDI in the long run, (for Australia, Canada and the United Kingdom). Section 8 concludes.

2 Real gross domestic product, labour productivity and real gross domestic income

Following Diewert and Morrison (1986) and Fox, Kohli and Warren (2002), suppose there are $N = N_D + N_X + N_M$ netputs that can be divided into domestic outputs, exported outputs and imported inputs (negative netputs) that can be represented by the following netput vector, $\underline{y} \equiv (\underline{y}_D, \underline{y}_X, \underline{y}_M)'$ with price vector $\underline{p} \equiv (\underline{p}_D, \underline{p}_X, \underline{p}_M)' > 0$. Suppose also that there is a one by M vector of primary inputs (labour and capital) $\underline{v} \equiv (v_1, \ldots, v_M)' \geq 0$ with price vector $\underline{w} \equiv (w_1, \ldots, w_M)' > 0$. It is then possible to calculate nominal GDP as the sum of final expenditures or the sum of payments to primary factors of production: $GDP = \underline{y} \bullet \underline{p}$

By assuming that $\underline{y}$ and $\underline{p}$ can be represented by indices, and letting $\underline{v} \bullet \underline{w} = Q$, it is possible to write the relationship between nominal GDP and nominal income as:

$$GDP = y \times p = Q \tag{1}$$

Real GDP is calculated by adjusting nominal GDP using a price index derived from input and output prices associated with production. This is equivalent to assuming the GDP deflator is the relevant price index for calculating real income, and leads to the interpretation of real GDP as a real income measure:

$$real\ GDP = y = \frac{Q}{p} \tag{2}$$

Real income measured in this way associates changes in income with changes in the volume of production. Because it uses the GDP deflator to do so, real income is measured in terms of the netputs produced, and therefore, is associated with movements relating to the economy's production function. As a result, changes in productivity, capacity utilization and inputs will change real income. This is only the case if all prices progress at the same rate, or if the economy is closed. In an open economy, where export, import and domestic prices change at different rates, changes in production do not necessarily result in changes commensurate to real income.

The relationship between GDP and nominal income can be used to form productivity measures that reflect the efficiency of production. One such measure is labour productivity, which tracks the volume of output per unit of labour input. Growth in labour productivity is associated with movements in real wages, making it an attractive metric for analyzing changes in economic performance over time. When the cost of labour and capital can be represented by indices, it is possible to decompose real GDP into three volume components: labour input, capital services and multifactor productivity. The labour index, h, is typically measured as the number of hours worked. Labour productivity is measured by factoring h out of the production function and using it to scale real GDP:

$$\text{Labour productivity} = \frac{y}{h} \tag{3}$$

Real GDP and labour productivity are associated with changes in an economy's production possibilities. It is possible however, to move to a real income concept that is more closely associated with a society's utility curve, by using a price index other than the GDP deflator. One choice for an alternative price index is the final domestic expenditure price index. It includes private consumption, gross fixed capital formation (GFCF), government consumption and inventory prices. The final domestic expenditure price index is the broadest price index available that captures the final goods and services purchased by domestic economic agents. When final domestic expenditure prices are used to deflate nominal income, the resulting measure is real GDI, as used in this paper:

$$Real\ GDI = y\frac{p}{p_D} = \frac{Q}{p_D} \tag{4}$$

Real income, measured using the final domestic expenditure deflator, associates changes in real income with changes in the volume of production, as well as relative price shifts. Changes in relative prices behave in a manner analogous to productivity growth (Diewert and Morrison 1986), and lead to real changes in the volume of goods and services available to an economy.

To empirically analyze the relationship between price and volume changes for real GDP and real GDI, an index number formula must be chosen. The Tornqvist (1936) index is used here. It has the attractive property of being log-additive, making it possible to interpret factors as contributions to growth. In addition to the ease of interpretation, the Tornqvist and Fisher ideal index are equivalent to a second-order approximation (Diewert 1978), which as Fox, Kohli and Warren (2002) point out, makes them equivalent, to at least two decimal points.

We define the logged Tornqvist final domestic expenditure price index between periods t and s as:

$$\ln\left(p_{D,t}/p_{D,s}\right) \equiv \sum_{j=1}^{N} \bar{v}_{j,t} \ln\left(\frac{p_{j,t}}{p_{j,s}}\right) \tag{5}$$

where $j = 1,\ldots,N_D$ netputs, $\bar{v}_{j,t} = \left(\frac{\varpi_{j,t} + \varpi_{j,s}}{2}\right)$ and $\varpi_{j,t} = y_j p_j / \underline{y} \bullet \underline{p}$.

When the final domestic expenditure price index is used, changes in real income can be written as the sum of changes in real GDP (production) plus relative price changes:

$$\underbrace{\ln\left(Q_t/Q_s\right)-\ln\left(p_{D,t}/p_{D,s}\right)}_{\text{Real income change}}=\underbrace{\ln\left(y_t/y_s\right)}_{\text{Change in real GDP}}+\underbrace{\ln\left(p_t/p_s\right)-\ln\left(p_{D,t}/p_{D,s}\right)}_{\text{Change in relative prices (trading gain)}} \tag{6}$$

Relative price changes are referred to as a trading gain, and represent the benefit/loss to an open economy from changes in price structures related to traded items.[1]

$$\underbrace{\ln\left(T_t/T_s\right)}_{\text{Change in trading gain}}=\underbrace{\ln\left(p_t/p_s\right)-\ln\left(p_{D,t}/p_{D,s}\right)}_{\text{Change in relative prices}} \tag{7}$$

Kohli (2006a) shows that the trading gain based on a final domestic expenditure deflator can be decomposed into a terms-of-trade contribution and a real exchange rate contribution:

$$\underbrace{\ln\left(T_t/T_s\right)}_{\text{Change in trading gain}}=\underbrace{\left(\frac{\overline{v}_{X,t}+\overline{v}_{M,t}}{2}\right)}_{\text{Average share of trade in GDP}}\underbrace{\ln\left(ToT_t/ToT_s\right)}_{\text{Terms of trade changes}}+\underbrace{\left(\overline{v}_{X,t}-\overline{v}_{M,t}\right)}_{\text{Share of net exports in GDP}}\underbrace{\ln\left(RER_t/RER_s\right)}_{\text{Real exchange rate changes}} \tag{8}$$

Where changes in the terms of trade are calculated as the difference between export and import price changes:

$$\underbrace{\ln\left(ToT_t/ToT_s\right)}_{\text{Terms of Trade Changes}}=\underbrace{\ln\left(p_{X,t}/p_{X,s}\right)}_{\text{Export Price Index Changes}}-\underbrace{\ln\left(p_{M,t}/P_{M,s}\right)}_{\text{Import Price Index Changes}} \tag{9}$$

Changes in the real exchange rate are calculated as the difference between the average change in traded goods prices and domestic prices.

$$\underbrace{\ln\left(RER_t/RER_s\right)}_{\text{Real exchange rate changes}}=\frac{1}{2}\left[\underbrace{\ln\left(p_{X,t}/p_{X,s}\right)}_{\text{Export price Jex changes}}+\underbrace{\ln\left(p_{M,t}/P_{M,s}\right)}_{\text{Import price index changes}}\right]-\underbrace{\ln\left(p_{D,t}/P_{D,s}\right)}_{\text{Final domestic expenditure price index changes}} \tag{10}$$

1. In the literature surrounding measurement in the System of National Accounts (SNA), the trading gain is derived from deflating net exports directly, rather than using an implicit price deflator. The SNA presents several options for deflating net exports, including import prices, export prices, an average of import and export prices or a final domestic expenditure price index. Consensus has not been reached about which method is most satisfactory (see: Gearly 1961, Stuvel 1956, Denison 1981, Silver and Mahdavy 1989, Nicholson 1960, Courbis 1969, Kurabayashi 1971, Kohli 2004, SNA 1993).
   By using an import price deflator the U.S. Bureau of Economic Analysis currently calculates a command basis GDP that is equivalent to the real GDI discussed in the SNA. A command GDP measure is also available from the Penn World tables annually, up to 2004.

The real exchange rate defined here is not the measure of the real exchange rate commonly used in macroeconomic literature. The more commonly employed real exchange rate adjusts a nation's nominal exchange rate for domestic price differences. The real exchange rate defined here, as Kohli (2006a) notes, is consistent with the real exchange rate defined in (as it has become known), the 'Australian model' (see Salter 1959, Corden 1960, Swan 1960). The real exchange rate is also consistent with balance of payments theory, since as Corden (1992) notes; the Australian model was used by Dornbusch (1974, 1980) to integrate money into balance of payments theory. It is also consistent with the 'booming sector' (or 'Dutch disease'), model of Corden and Neary (1982) and Corden (1984). The real GDI measure, defined by using the final domestic expenditure deflator is, therefore, a general equilibrium real income concept.

3 Data and methods

Calculations use national accounts data collected by the OECD. For each country, the most recent data vintage is employed. This limits the span of the data for many countries, with the result that long-run calculations are reported only for Australia, Canada, the United Kingdom and the United States. Calculations covering the resource boom of 2003 to 2007 employ the widest possible sample of countries. The national accounts data contain information on private consumption, GFCF, public consumption and export and imports. The OECD does not provide the domestic expenditure deflator; instead, it is calculated from the published data, by removing the influence of export and import prices from the GDP deflator.

Labour productivity measures by country are taken from the OECD data, which extend no further back than 1970, and in many cases cover a shorter time span. Data starting in 1970 is employed for Australia, Canada, the United Kingdom and the United States. For all other nations except Turkey (for which the OECD does not provide a labour productivity measure), data for the period 2003 to 2007 are used. Where Turkey appears in analysis, only real GDP and real GDI are employed.

Population data from the OECD are used to scale estimates of real GDP and real GDI when international comparisons are made, or where labour productivity is compared to real income statistics. Per capita measures are reported because per capita growth provides a more accurate reflection of changes in living standards across countries. Per capita measures are also more appropriate for comparisons with labour productivity.

Trade data, used to construct a measure of resource sensitivity, are taken from the OECD trade database. Trade data contains information about nominal expenditures on different types of goods only.

Data on resource prices are taken from the Bank of Canada's commodity price index. The index is comprised of US$ prices for a wide range of commodities (see Hirsch 2003 for details). Because the trading gain is comprised of relative price ratios, the U.S. Bureau of Labor Statistics' durable goods consumer price index (CPI) is used to scale commodity prices.

4 Real GDP and labour productivity vs. real GDI, 2003 to 2007

The 2003-2007 years are particularly important for examining real GDI per capita changes because they cover the largest commodity boom since the end of the Second World War. The influence of commodity price changes is larger and more apparent after 2002 than for almost any time in the previous 45 years. As a consequence, real GDP per capita and labour productivity are less than ideal for understanding how the standard of living was adjusted during this period.

Between 2003 and 2007, differences arise in many OECD nations, between real GDP per capita, labour productivity and real GDI per capita growth (Table 1). Real GDI per capita in resource-rich, commodity exporting countries like Australia and Norway outpaces growth in real GDP per capita and labour productivity. In manufacturing-centered, commodity importing nations like Japan and the United States, real GDP per capita and labour productivity rise faster than real GDI per capita.

The differences between measures stem, in large part, from terms-of-trade changes. The trading gain decomposition in equation (8) illustrates why: The impact of terms-of-trade changes on real income is proportional to the average share of imports and exports in GDP, while the impact of the real exchange rate is proportional to the share of net exports in GDP. Consequently, the more a country is open to trade, the more susceptible it will be to terms-of-trade changes, while the larger a country's trade imbalance is, the more susceptible it will be to real exchange rate movements. Between 2003 and 2007, across OECD nations, the share, on average, of exports and imports in GDP is 44.5%, while the average absolute trade balance in GDP is 5.5% (Table 2). This can be interpreted as terms-of-trade shifts being ten times more important for real income growth than for real exchange rate changes, but about half as important as changes in production (real GDP), which has a unitary weight in the real GDI decomposition in equation(6).

Table 1
Average annual real gross domestic product (GDP), real gross domestic income (GDI) and labour productivity growth, 2003 to 2007

	Labour productivity	Real GDP per capita	Real GDI per capita
		percent	
Australia	1.2	2.0	3.4
Austria	1.8	1.9	1.8
Belgium	1.4	1.7	1.5
Canada	0.9	1.7	2.9
Czech Republic	4.6	5.2	5.1
Denmark	1.5	1.8	2.0
Finland	2.5	3.1	2.2
France	1.4	1.3	1.2
Germany	1.2	1.5	1.3
Greece	2.3	3.9	4.2
Hungary	3.7	3.8	3.4
Iceland	2.6	3.6	3.6
Ireland	2.4	3.3	1.8
Italy	0.0	0.6	0.5
Japan	2.0	2.0	1.4
Korea	4.5	4.0	2.8
Luxembourg	2.7	3.2	4.9
Netherlands	0.8	2.0	1.9
New Zealand	1.0	1.9	2.7
Norway	1.2	2.0	4.8
Poland	3.0	5.1	5.5
Portugal	1.5	0.5	0.6
Slovak Republic	5.1	6.8	6.3
Spain	1.0	1.8	1.9
Sweden	2.3	2.7	2.5
Switzerland	1.0	1.6	1.2
Turkey	.	6.3	6.5
United Kingdom	2.1	2.1	2.2
United States	1.8	1.8	1.6

Most nations have, on average, shares of imports and exports in GDP between 25% and 50%. There are some nations however, where real income is more sensitive to terms-of-trade changes, particularly Luxembourg (143.7%); Belgium (83.1%); the Slovak Republic (79.6%), and; the Czech Republic (69.5%). On the other hand, there are nations where real income will be less sensitive to terms-of- trade shifts, notably the United States (13.0%) and Japan (13.3%). The share of net exports in GDP tends to be between 5% and 15%, but there are some exceptions, like Luxembourg (26.2%) and Italy (0.1%).

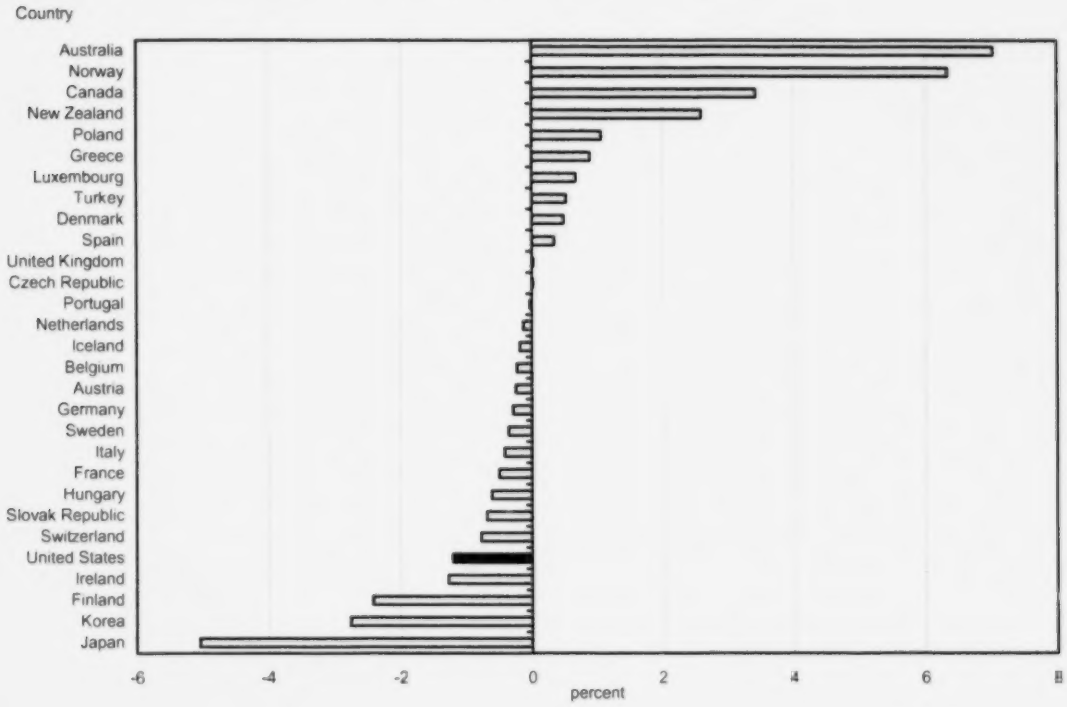
The importance of the terms-of-trade changes for real income growth calls for an examination of what drives terms-of-trade adjustments. Movements in the terms of trade for OECD countries over the 2003-to-2007 period are the result of relative price movements between resources and manufactured products. For relatively resource-rich nations, the terms of trade represents the opportunity cost of trading manufactured goods for resources, while for relatively resource-poor nations the terms of trade captures the opportunity cost of trading resources for manufactured products. When resource bcoms occur, changes in the terms of trade redistribute purchasing power across countries. The size of the trade redistribution depends on a country's endowments, comparative advantages and trade openness.

Table 2
Relative price change weights in gross domestic product (GDP) and contributions to real gross domestic income (GDI) per capita growth, 2003 to 2007

	Weights in GDP		Contributions to real GDI per capita		
	Average share of trade in GDP	Net export share of GDP	Real GDP per capita	Terms of trade	Real exchange rate
			percent		
Australia	20.2	-1.9	2.0	1.4	0.0
Austria	50.9	4.3	1.9	-0.1	0.0
Belgium	83.1	3.9	1.7	-0.2	0.0
Canada	36.0	3.5	1.7	1.2	-0.1
Czech Republic	69.5	1.2	5.2	0.0	0.0
Denmark	46.1	4.5	1.8	0.2	0.0
Finland	38.6	6.1	3.1	-0.9	0.0
France	26.3	-0.2	1.3	-0.1	0.0
Germany	37.8	5.2	1.5	-0.1	0.0
Greece	27.6	-12.3	3.9	0.2	0.1
Hungary	68.6	-1.4	3.8	-0.4	0.1
Iceland	38.0	-8.7	3.6	0.0	0.0
Ireland	76.4	13.6	3.3	-1.0	-0.5
Italy	26.2	0.1	0.6	-0.1	0.0
Japan	13.3	1.5	2.0	-0.7	0.1
Korea	40.4	2.2	4.0	-1.1	-0.1
Luxembourg	143.7	26.2	3.2	0.8	0.9
Netherlands	64.5	7.6	2.0	-0.1	0.0
New Zealand	29.6	-0.7	1.9	0.8	0.0
Norway	35.8	15.1	2.0	2.3	0.6
Poland	37.7	-2.1	5.1	0.4	0.0
Portugal	33.2	-7.9	0.5	0.0	0.1
Slovak Republic	79.6	-3.4	6.8	-0.6	0.1
Spain	28.5	-4.5	1.8	0.1	0.1
Sweden	43.9	7.6	2.7	-0.1	0.0
Switzerland	44.8	7.1	1.6	-0.4	0.0
Turkey	24.3	-2.8	6.3	0.1	0.1
United Kingdom	27.8	-2.9	2.1	0.0	0.0
United States	13.0	-5.2	1.8	-0.2	0.0

Plotting—from largest to smallest—the terms-of-trade adjustments experienced by OECD countries between 2003 and 2007 illustrates the nature of the redistribution that can occur as commodity prices rise (Chart 1). Resource-exporting countries like Australia, Norway, Canada and New Zealand experienced the largest terms-of-trade improvements, while resource-importing nations like Japan, Korea, Finland and the United States experienced terms-of-trade deteriorations.

Chart 1
Terms of trade changes across OECD countries



A more formal way to illustrate the relationship between resources and terms-of-trade changes is to construct a measure of the importance of resources to trade flows, and then compare it with changes in the terms of trade. A resource sensitivity indicator, based on 1-digit Standard International Trade Classification Codes, is constructed here.

The resource sensitivity indicator is the difference between the share of resources in exports and the share of resources in imports:

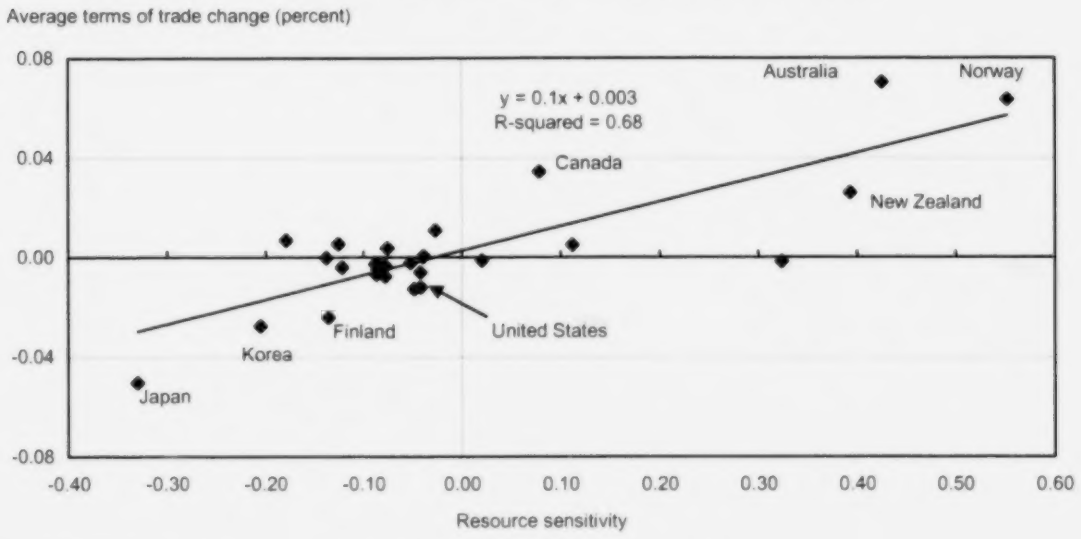
$$\text{Resource sensitivity} = 1 \geq \frac{X_{resources}}{X_{total}} - \frac{M_{resources}}{M_{total}} \geq -1 \qquad (11)$$

Resource activities are defined as imports or exports of Food and live animals, Crude materials, inedible, except fuels and Mineral Fuels, lubricants and related materials.

A country that exports only resources—and imports only manufactured products—will have a score of 1, while a country that exports only manufactured products—and imports only resources—will have a score of -1. A country that does not trade in resources, or that has an equal share of resources in imports and exports, will have a score of 0.

When the OECD nations' average resource sensitivity, after 2002, is compared with their average terms-of-trade changes, a statistically significant, positive relationship emerges (Chart 2). Approximately two-thirds of the cross-sectional variation in average terms-of-trade changes can be explained by the resource sensitivity measure. Nations experiencing the largest terms-of-trade improvements are resource-rich, like Norway and Australia, while net importers of commodities, like Japan and Korea, experience the largest terms-of-trade deteriorations.

Chart 2
Resource sensitivity versus terms-of-trade changes, 2003 to 2007



Note: Greece is missing.

5 Real income and economic aggregates, 2003 to 2007

In the short run, changes in real income may affect changes in real consumption and investment. As production rises and relative prices change, the volume of goods and services available to the domestic economy changes. Increasing real GDP and trading gains both signal that the potential volume of goods and services that may be consumed or invested are rising. As a result, real consumption and GFCF can rise faster than real GDP. If the trading gain works against real GDP, then real consumption and real GFCF will rise more slowly than real GDP.

The importance of the trading gain for real income growth after 2002 makes it difficult to understand changes in real private consumption, real GFCF, or real government expenditures across OECD countries, if the trading gain is not factored in. By using linear regressions, the relationship between economic aggregates and the trading gain can be illustrated. The average changes in real production (real GDP) and the trading gain are regressed on changes in real private consumption, real GFCF, and real government consumption. If the trading gain contributes to changes in domestic expenditures, it will have a statistically significant and positive coefficient.

Table 3 presents cross-section regression results for OECD countries. Variation in economic aggregate growth across OECD countries is related to changes in both real GDP and changes in the trading gain. For real private consumption, the combination of real GDP growth and changes in the trading gain explains about three-quarters of the variation across the OECD countries; about two-thirds of the changes in real GFCF; and, about one-half of the changes in

real government consumption. For all of the real aggregates, the coefficient on the trading gain is positive and statistically significant at the 5% nominal level[2].

Table 3
Regression results for annual averages of OECD countries, 2003 to 2007

	Real private consumption	Real gross fixed capital formation (GFCF)	Real government consumption
Variables			
Intercept			
coefficient	0.02	-0.43	0.10
p-value	0.95	0.67	0.93
Real GDP growth			
coefficient	0.95	1.66	1.16
p-value	0.00	0.00	0.00
Trading gain			
coefficient	0.72	1.70	1.53
p-value	0.00	0.00	0.01
Diagnostic statistics			
R-squared	0.77	0.66	0.48
Observations (number)	28.00	28.00	28.00

Note: OECD databases do not have entries for real GFCF and real government consumption for Greece. An unreported dummy variable is used to account for the impact of the missing data. An examination of residual values suggested that Luxembourg is an aberrant observation. It is removed from the dataset used for regressions.

The results can be interpreted as follows. Between 2003 and 2007, real GDP increased in all OECD countries. At the same time, the price of commodities rose sharply, affecting terms of trade. The purchasing power of output was redistributed across nations based on their endowments. Real consumption and real GFCF advanced more than real production in resource-rich nations. In resource-poor nations, rising commodity prices, particularly for energy, led to lower increases in real consumption and real GFCF than changes in the volume of production would have suggested.

6 Economic performance relative to the United States, after 2003

Changes in GDP per capita, or labour productivity over time, are often interpreted as being synonymous with changes in the living standards of an economy. Comparisons across countries are made by examining changes in one country relative to another. While this is instructive, only in the event that domestic and trade prices progress at the same rate or, that both economies are closed will the measures of real GDP per capita necessarily reflect relative real income changes that are captured by real GDI. Similarly, international comparisons which use

2. The elasticity estimates for government consumption suggest that governments benefit from trading gains. However, the model here is a reduced form equation, and the route through which the government benefits is not explained in detail. It is expected that relative price changes will affect government revenues through two main channels: One: there will be a direct effect in those nations whose governments collect resource royalties or, where rising resource prices lead to higher profits and hence, higher income tax revenue. A second channel arises when governments levy value-added taxes on consumption. As relative prices adjust, the volume of consumption adjusts, leading to possibly two offsetting movements: the volume of consumption changes, which —ceteris paribus —, changes taxable expenditures. Taxes are levied on nominal expenditures, so it is the combination of the price and volume that matter. These movements can be either reinforcing or offsetting.

productivity measures to examine the relative changes in efficiency only reflect changes related to production. These latter comparisons do not incorporate the role of relative price changes on purchasing power and are, therefore, less comprehensive than comparisons made using real GDI per capita. The ability of real GDI per capita to incorporate purchasing power changes into international comparisons makes it a more appropriate real income statistic for international comparisons among open economies.

OECD nations are examined here relative to the United States, for the period 2003-to-2007 Since the United States is often viewed as the technological frontier: each country's performance is measured against whether it is catching up to, or falling behind, the United States.

Table 4
Average annual growth relative to the United States, 2003 to 2007

	Labour productivity	Gross domestic product per capita	Gross domestic income per capita
		percent	
Australia	-0.6	0.2	1.8
Austria	0.0	0.1	0.2
Belgium	-0.4	-0.1	-0.1
Canada	-0.9	-0.1	1.2
Czech Republic	2.7	3.4	3.6
Denmark	-0.3	0.0	0.4
Finland	0.7	1.3	0.6
France	-0.4	-0.5	-0.4
Germany	-0.6	-0.3	-0.3
Greece	0.5	2.1	2.6
Hungary	1.9	2.0	1.8
Iceland	0.8	1.8	2.0
Ireland	0.6	1.5	0.2
Italy	-1.7	-1.2	-1.1
Japan	0.2	0.2	-0.2
Korea	2.6	2.2	1.2
Luxembourg	0.8	1.4	3.4
Netherlands	-1.0	0.2	0.3
New Zealand	-0.8	0.1	1.1
Norway	-0.6	0.2	3.3
Poland	1.2	3.3	3.9
Portugal	-0.3	-1.2	-1.0
Slovak Republic	3.2	5.1	4.8
Spain	-0.8	0.0	0.3
Sweden	0.5	0.9	0.9
Switzerland	-0.8	-0.2	-0.4
Turkey	.	4.6	5.0
United Kingdom	0.3	0.3	0.5

Note: Negative values indicate a decline relative to the United States.

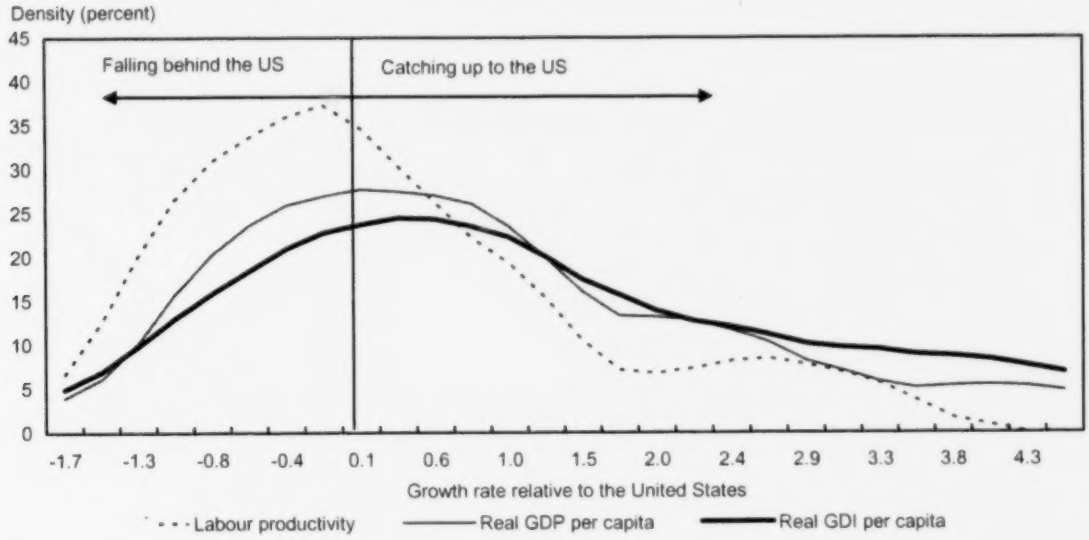
Conclusions about the relative performance of the OECD nations varies, depending on whether labour productivity, real GDP per capita or real GDI per capita is used (Chart 3 and Table 4)[3]. In resource-exporting nations, labour productivity and real GDI provide different outcomes relative to the United States. Australia, Canada, New Zealand and Norway exhibit patterns of declining

3. Kohli 2006b illustrates the effect on Hong Kong of going from real GDP to real GDI. His results show that growth in real income outpaced real GDP growth by 0.4 percentage points per year, on average from 1963 to 2003.

relative labour productivity, but rising relative real GDI per capita. In Japan, the opposite pattern emerges: relative labour productivity increases, while relative real GDI per capita declines.

When the nations are treated as a statistical sample, the distribution of relative performance (based on labour productivity), is grouped around zero. Just under one-half of all OECD countries experienced a gain in labour productivity relative to the United States during the 2003-2007 period. The distributions of GDP per capita and GDI per capita are flatter and skewed to the right, as more countries gain than lose ground to the United States. When labour productivity is used as the metric for comparison, 48% progress more rapidly than the United States. When relative real GDP per capita is used, 71% of countries advance more rapidly, and when GDI per capita is used, 75% of countries in the sample grow faster than the United States.

Chart 3
Distributions of relative growth for labour productivity, real gross domestic product (GDP) per capita and real gross domestic income (GDI) per capita



The speed with which nations gain, or lose, ground in the short run depends on the metric used for comparison. The smallest relative gains or losses occur when the metric used is labour productivity. Moving to real GDP per capita and real GDI per capita increases the relative changes. On average, gainers go from a relative increase of 1.2% per year for labour productivity, to 1.6% per year for real GDP per capita and 1.9% for real GDI per capita. Those losing ground go from an average relative decline of -0.7% per year for labour productivity, to -0.5% for real GDP per capita and real GDI per capita.

From 2003 to 2007, moving from relative labour productivity to relative GDP per capita (or real GDI per capita), changes the relative performance of roughly 20% of OECD countries in the sample. Australia, Canada, New Zealand, Norway and Spain go from losing to gaining ground, while Japan goes from gaining to losing ground. The metric used alters perceptions of how a nation is performing, as well as how quickly it is catching up, or falling behind.

7 Real GDP and labour productivity vs. real GDI in the long run

Between 2003 and 2007, the trading gain was an unprecedented source of real income growth that accelerated (or decelerated), changes in real GDI per capita relative to labour productivity and real GDP per capita. While resource prices led to significant relative price shocks in the past (notably during the oil shocks of the 1970s), their influence during this period is anomalous, as is the divergence that occurred between metrics used to compare economic performance across nations. When labour productivity, real GDP per capita and real GDI per capita are viewed over longer time spans, the unusual nature of the years between 2003 to 2007 becomes apparent.

The latest data vintage in the OECD database extends back to 1961 for Australia, Canada, the United Kingdom and the United States. The performance of the first three relative to the United States for the 1961 to 2007 period illustrates the historically large impact of the trading gain after 2002.

Table 5
Real gross domestic product (GDP) growth versus real gross domestic income (GDI) growth for Australia, Canada, the United Kingdom and the United States

	1962 to 2007	1971 to 2007	1962 to 1972	1973 to 1978	1979 to 1986	1987 to 1990	1991 to 1997	1998 to 2002	2003 to 2007
					percent				
Australia									
Real GDP	2.2	1.8	3.1	1.3	1.7	2.0	1.9	2.6	2.0
Real GDI	2.3	1.9	3.1	1.1	1.3	2.7	1.8	2.8	3.4
Labour productivity	...	1.7	...	1.8	1.4	0.4	2.5	2.1	1.2
Canada									
Real GDP	2.3	1.9	3.3	2.9	1.7	1.5	1.0	2.9	1.7
Real GDI	2.4	2.2	3.3	3.2	1.6	1.9	0.9	2.8	3.0
Labour productivity	...	1.4	...	2.0	1.0	0.6	1.6	2.0	0.9
United Kingdom									
Real GDP	2.2	2.2	2.3	2.2	1.8	2.9	1.8	2.8	2.1
Real GDI	2.2	2.2	2.4	1.5	2.0	3.1	1.9	3.0	2.1
Labour productivity	...	2.3	...	2.3	2.3	1.0	2.4	2.3	2.1
United States									
Real GDP	2.2	2.0	3.1	2.4	1.9	2.2	1.6	1.8	1.8
Real GDI	2.1	1.9	3.1	2.1	1.8	2.0	1.7	1.9	1.5
Labour productivity	...	1.6	...	1.5	1.4	1.0	1.4	2.3	1.8

For all four countries the average annual growth rates of real GDP and real GDI are virtually identical over long time spans and do not differ greatly from long-run labour productivity growth (Table 5). Over shorter time spans, differences emerge as the trading gain accelerates (or decelerates), real GDI growth. During the 1970s and after 2002, the trading gain is a particularly important source of real income growth. In Canada, during the 1970s, real GDI growth accelerated relative to real GDP, while it decelerated relative to real GDP in Australia, the United Kingdom and the United States.

During the 1980s and 1990s, real GDI growth fluctuated around real GDP growth. For several years, real GDI rose faster than real GDP, only to fall back later. For all four countries, the pattern of more rapid and then, slower growth is repeated. Since 2002, the largest divergence on record has occurred. In Australia and Canada, real GDI growth outpaced real GDP growth, while in the United States real GDI growth did not keep pace with real GDP growth. There was little difference in real GDP or real GDI growth rates in the United Kingdom.

The cyclical nature of the gains or loses leads to higher volatility for real GDI than for production based measures. The standard deviation of real GDI growth is greater than the standard deviation of labour productivity or real GDP per capita, for all four nations. Allowing for relative price–induced purchasing power changes leads to a real income measure that implies greater uncertainty for economic agents.

Table 6
Standard deviations of growth rates, 1971 to 2007

	Labour productivity	Real gross domestic product (GDP) per capita	Real gross domestic income (GDI) per capita
		percentage points	
Australia	1.9	1.8	2.3
Canada	1.1	2.0	2.5
United Kingdom	1.5	1.9	2.0
United States	1.1	1.9	2.0

Note: Over the entire sample period, real GDP per capita and real GDI per capita show a similar increase in volatility between production and purchasing power adjusted real income measures.

The starkest difference emerges for the resource exporting countries, Australia and Canada. Over the long run, their real GDP per capita, real GDI per capita and labour productivity progressed at similar rates, but with noteworthy differences in variance across measures. Over the short run, real GDI per capita predictably outpaced, and then lagged behind, real GDP growth repeatedly. When commodity prices rose, real GDI per capita tended to accelerate in Canada and Australia and decelerate in the United States. When commodity prices weakened, real GDI per capita performed well relative to real GDP per capita in the United States, but performed poorly relative to real GDP per capita in Australia and Canada. The 1970s oil shocks, the 1986 energy price collapse and the post-2002 commodity boom are all periods during which real GDI per capita and real GDP per capita growth rates diverged.

The economic performance of Australia and Canada relative to the United States tended to be determined by movements associated with production from 1961 to 2001 (Charts 4 and 5). Movements in relative GDI per capita followed the same pattern as movements in relative real GDP per capita. While trading gains led to larger relative changes in GDI per capita—particularly during the first and second oil shocks—it was changes in inputs and productivity that ultimately determined differences in relative economic performance.

Chart 4
Long-run economic performance, Australia relative to United States

index (2002=100)

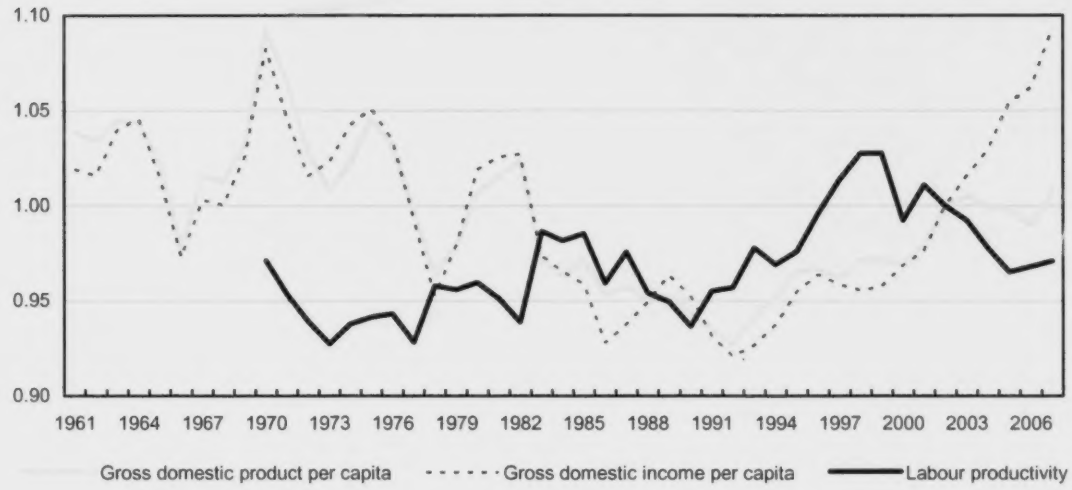
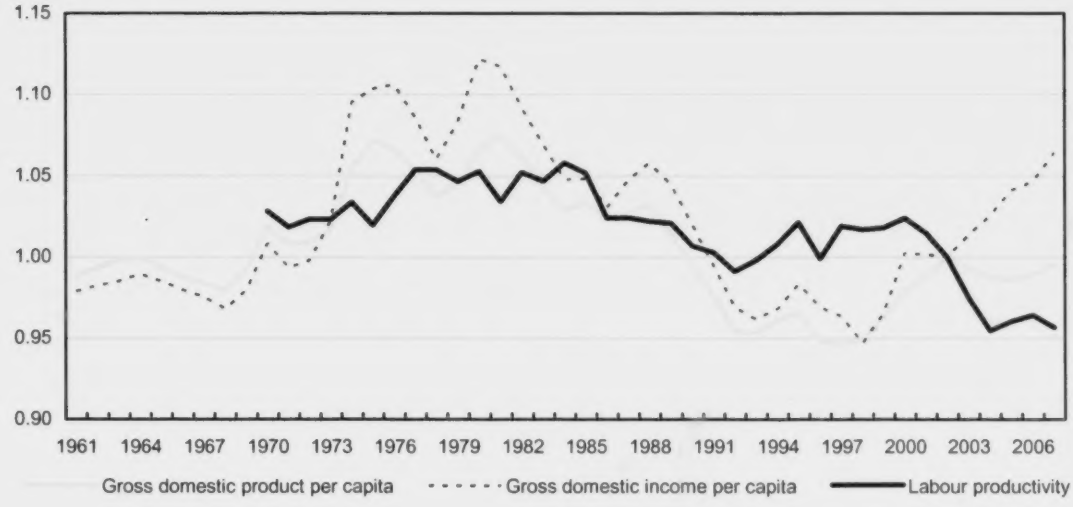


Chart 5
Long-run economic performance, Canada relative to the United States

index (2002=100)



After 2001, terms-of-trade improvements for Australia and Canada, coupled with terms-of-trade deteriorations for the United States, led to a divergence between relative labour productivity, GDP per capita and GDI per capita. Labour productivity in resource-rich Australia and Canada failed to keep pace with labour productivity growth in the United States, while real GDP per capita did keep pace. Real GDI per capita for Australia and Canada shows gains relative to the United States between 2002 and 2007.

The long-run analysis reveals that commodity price cycles have been an important source of real income fluctuations in developed countries for an extended period of time. One way to

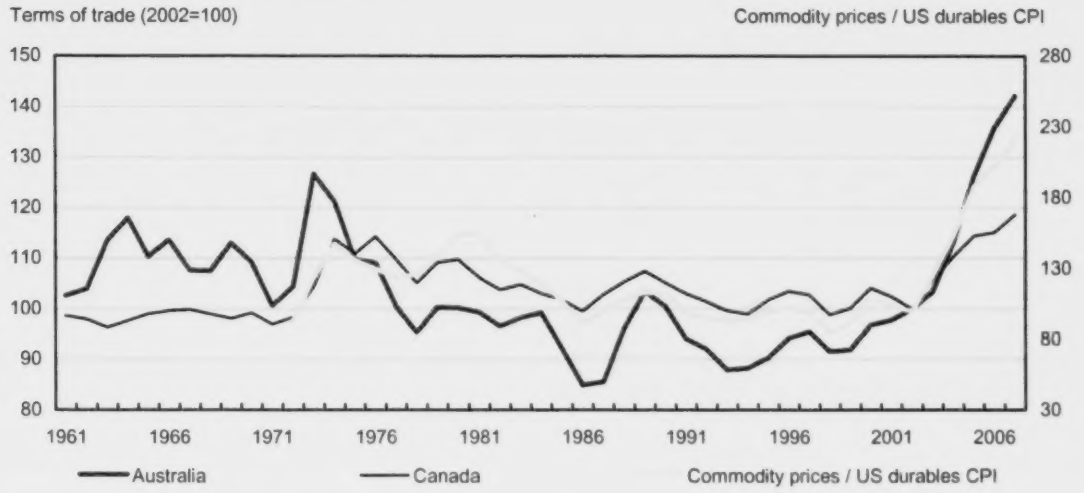
illustrate the influence of resource cycles on terms-of-trade shifts is to examine the relationship between terms of trade and commodity prices for individual countries over time. Assuming that the terms of trade reflects the price of commodities relative to manufactured goods, a relative commodity price is used in analysis.

The commodity price index employed here covers a wide range of primary commodities priced in US dollars (see Hirsh 2003 for details). To generate a relative commodity price, free from the influences of nominal exchange rate fluctuations, the US CPI durable manufactured goods price index is used as a US dollar measure of manufacturing prices to scale the commodity price index.

Canada and Australia export a variety of commodities, making their terms of trade sensitive to price changes in many different types of primary products, while the United States imports many commodities, but is particularly sensitive to energy prices.[4]

Between 1961 and 2007, the terms of trade for Australia and Canada followed regular commodity price cycles (Chart 6), and did not have a long-run effect on real income growth. Cyclical commodity price changes led to alternating terms-of-trade improvements and deteriorations, increasing the volatility of real income, but not affecting its trend.

Chart 6
Commodity prices / US durables consumer price index (CPI) versus terms of trade for Australia and Canada



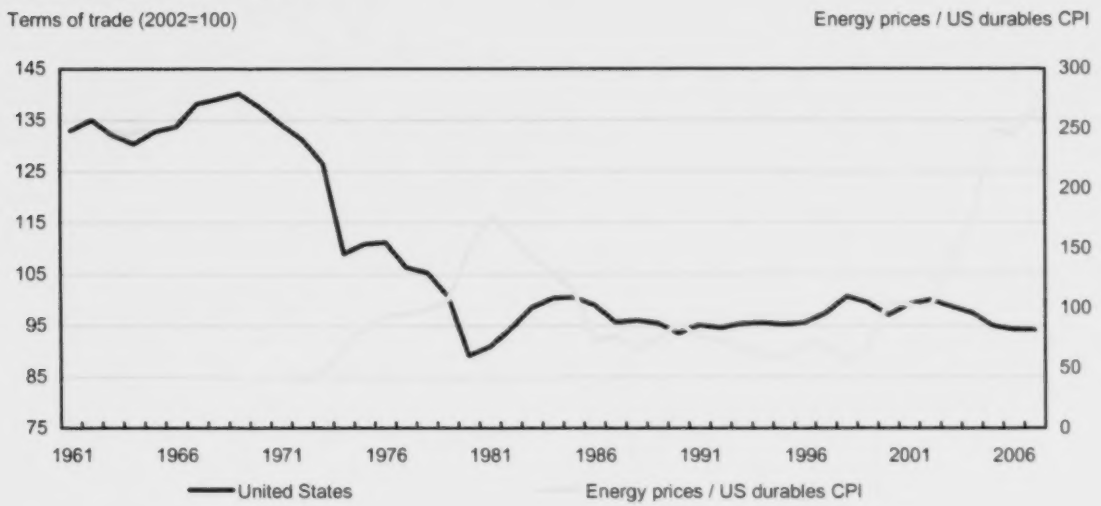
Between 1961 and 2007, the terms of trade for the United States reflected changes in the relative price of energy. The two largest terms-of-trade shifts occurred during the oil shocks (Chart 7). Between 1970 and 1980, the cumulative effect of the oil supply disruptions was a

4. The Bank of Canada Commodity Price Index is used as a measure of resource prices. It captures movements in primary resource prices using weights appropriate for Canada. It is not an ideal measure of commodity prices for Australia. Nevertheless, because Australia and Canada export a wide range of commodities, the index follows shifts in global commodity demand that are relevant for both countries.
Similarly, the Energy Price Index (used to illustrate the relationship between U.S. terms of trade and energy prices) is a sub-index of the Bank of Canada Commodity Price Index. While not ideal, it does capture the relevant energy price changes that affect the United States.

deterioration of 35.2% in the terms of trade for the United States. Unlike the cyclical movements in Australia and Canada, most of the deterioration in the United States was permanent.[5]

In addition to the oil shocks, energy prices also rose sharply during the latest resource boom. The increase in energy prices however, did not have as large an impact on US terms-of-trade, which declined by 5.8% between 2002 and 2007. One reason why a difference may appear is described in Reinsdorf (2008), who argues that prices of non-energy imports supported the terms of trade between 2002 and 2007, partially offsetting the effect of rising energy prices. A second reason may be that energy prices did not rise by as much after 2002, as before. From 1972 to 1981, the oil shocks led to a 720% rise in energy prices. From 2002 to 2007, energy prices rose 146% (less than one-third of the increase during the oil shocks of the 1970s). If 1998 is used (instead of 2002) as the low-point in energy price cycles, then the increase in energy prices rises to 328%, which is still less than half of what was generated by the oil shocks of the 1970s.

Chart 7
Energy prices / US durables consumer price index (CPI) versus terms of trade for the United States



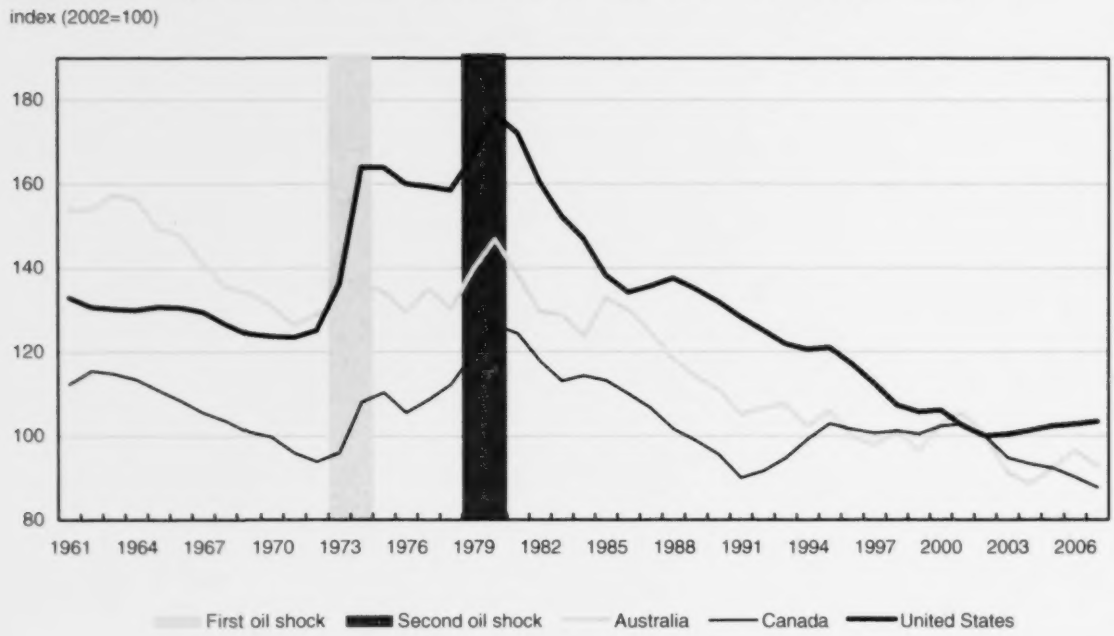
The real exchange rate can also be influenced by commodity price fluctuations, and although their effects may be more muted because of their relatively low weight in the GDI decomposition. Nevertheless, the long-run impact of commodity prices still warrants examination. Changes in the real exchange rate over long periods of time reflect differential changes between goods and services sectors: While there is trade in services, the majority of traded items are goods. As a result, the composition of domestic purchases is weighted more towards services than is the composition of traded items. Because traded items include commodities whose prices are cyclical (but without a trend), and manufactured goods prices fall relative to services over time, traded prices do not rise as quickly as domestic prices. The real exchange rate, therefore, tends to decline over long periods.

5. In the United Kingdom, the first oil shock led to a 20.6% deterioration in the terms of trade between 1972 and 1974. Most of the decline was unwound by the late 1970s. The second oil shock did not generate a second deterioration, because of energy exports from newly-developed North Sea deposits.

The profitability of traded and non-traded sectors changes as the real exchange rate changes. A declining real exchange rate acts to raise investment and employment in non-traded industries relative to traded industries (Corden and Neary 1982). In addition to their short-run influence on real income growth, shifts in the real exchange rate also influence changes in an economy's productive activity.

Over shorter periods of time, movements in commodity prices and currencies can eclipse the long-run determinants of real exchange-rate change. Oil shocks, currency crises and commodity booms all lead to real exchange-rate changes in the short run. In many cases, periods of real exchange rate increases are accompanied by increased uncertainty and unemployment. In Australia, Canada and the United States, the oil shocks led to real exchange rate increases between 1973 and 1974, and again between, 1979 and 1980 (Chart 8).[6]

Chart 8
Real exchange rate over time, Australia, Canada and the United States



8 Conclusion

In a world where international trade is an important activity, real income depends not only on the volume of production, but also on the volume of goods and services that production commands on world markets. A country may appear to better its income levels when production-based real income measures (like real GDP per capita), are used, but if it produces items whose relative price is declining, it may not see much of an increase in the purchasing power of that income. Measures of real income, like real GDI per capita, which incorporates production and purchasing power changes can be derived from widely available national income statistics.

6. The first oil shock led to an increase in the real exchange rate for the United Kingdom. In Korea, the oil shocks and the 1997 Asian Financial Crisis led to increases of the real exchange rate.

Purchasing power is measured through a trading gain, which is composed of two related relative prices: the terms of trade and the real exchange rate. The terms of trade is the ratio of export to import prices, and the real exchange rate is the ratio of the geometric mean of export and import prices to an index of final domestic expenditures. For most OECD countries, the impact of the terms of trade is around ten times larger for real income growth than changes in the real exchange rate.

The terms of trade basically captures a trade-off between resources and manufactured products. During the 2003-2007 commodity boom, terms-of-trade changes redistributed purchasing power across the OECD. Resource–rich nations tended to experience increases in real consumption, (or real GFCF), which outpaced growth in real GDP. Resource-importing nations, on the other hand, tended to experience increases in real consumption and real GFCF that lagged behind real GDP growth.

The relationship between the terms of trade and resource prices, and the effect of relative price shifts on real income growth across the OECD from 2003 to 2007, produced a short-run boost in real income in some countries that, by historical standards, was large. During the commodity boom, being a resource-rich, resource exporting nation was beneficial.

Moving to real GDI affects not only the interpretation of economic aggregates and the role of resources in economic growth, but also influences the outcomes of international comparisons. Comparing measures of GDP per capita or labour productivity across countries over time can generate different results from trading gain adjusted real income measures during periods of rapid relative price change.

References

Baldwin, J.R., and W. Gu. 2007. *Long-term Productivity Growth in Canada and the United States, 1961 to 2006.* Statistics Canada Catalogue no. 15-206-X. Ottawa. The Canadian Productivity Review. No. 13.

Commission of the European Communities - Eurostat, International Monetary Fund, Organisation for Economic Co-operation and Development, United Nations and World Bank. 1993. *System of National Accounts 1993.* Brussels/Luxembourg, New York, Paris, Washington (D.C.). Prepared under the auspices of the Inter-Secretariat Working Group on National Accounts.

Corden, W.M. 1960. "The geometric representation of policies to attain internal and external balance." *The Review of Economic Studies.* Vol. 28. No. 1. p. 1–22.

Corden, W.M. 1984. "Booming sector and dutch disease economics: Survey and consolidation." *Oxford Economics Papers. New Series.* Vol. 36. No. 3. p. 359–380.

Corden, W.M. 1992. "The dependent economy model of the balance of payments." *New Palgrave Dictionary of Money and Finance.* P. Newman, M. Milgate and J. Eatwell (eds.). London. MacMillan.

Corden, W.M., and J.P. Neary. 1982. "Booming sector and de-industrialization in a small open economy." *The Economic Journal.* Vol. 92. No. 368. p. 825–848.

Courbis, R.W. 1969. "Comptabilité nationale à prix constants et à productivité constante." *Review of Income and Wealth.* Vol. 15. No. 1. p 33–76.

Denison, E.F. 1981. "International transactions in measures of the nation's production." *Survey of Current Business.* Vol. 61. No. 5. p. 17–28.

Diewert, W.E. 1978. "Superlative index Numbers and consistency in aggregation." *Econometrica.* Vol. 46. No. 4. p. 883–900.

Diewert, W.E., and C.J. Morrison. 1986. "Adjusting output and productivity indexes for changes in the terms of trade." *The Economic Journal.* Vol. 96. No. 383. p. 659–679.

Dornbusch, R. 1974. "Real and monetary aspects of the effect of exchange rate changes." *National Monetary Policies and the International Financial System.* R.Z. Aliber (ed.). Chicago. University of Chicago Press.

Dornbusch, R. 1980. *Open Economy Macroeconomics.* New York. Basic Books Inc.

Fox, K.J., U. Kohli and R.S. Warren Jr. 2002. "Accounting for growth and output gaps: Evidence from New Zealand." *The Economic Record.* Vol. 78. No. 242. p. 312–326.

Francis, M. 2007. "The effect of China on global prices." *Bank of Canada Review*. Autumn. p. 13–25.

Geary, R.C. 1961. "Problems in the deflation of national accounts: Introduction." *Review of Income and Wealth*. Vol. 9. No. 1. p. 3–8.

Hirsch, T. 2003. "Updating the Bank of Canada commodity price index." *Bank of Canada Review*. Spring. p. 31–33.

Hulten, C.R. 2001. "Total factor productivity: A short biography." *New Developments in Productivity Analysis*. C.R. Hulten, E.R. Dean and M.J. Harper (eds.). Chicago. University of Chicago Press. p. 1–54.

Kohli, U. 2004. "Real GDP, real domestic income, and terms of trade changes." *Journal of International Economics*. Vol. 62. No. 1. p. 83–106.

Kohli, U. 2006a. "Real GDP, real GDI, and trading gains: Canada, 1981-2005." *International Productivity Monitor*. Vol. 13. Fall. p. 46–56.

Kohli, U. 2006b. *Terms-of-Trade Changes, Real GDP and Real Value Added in the Open Economy: Reassessing Hong Kong's Growth Performance*. Hong Kong Institute for Monetary Research. Working Paper No. 052006.

Kurabayashi, Y. 1971. "The impact of changes in terms of trade on a system of national accounts: An attempted synthesis." *Review of Income and Wealth*. Vol. 17. No. 3. p. 285–297.

Nicholson, J.L. 1960. "The effects of international trade on the measurement of real national income." *The Economic Journal*. Vol. 70. No. 279. p. 608–612.

Reinsdorf, M. 2008. "Measuring the effect of changes in the terms of trade on income, exports and prices." *Bureau of Economic Analysis Advisory Committee*. Washington. November 7. http://www.bea.gov/about/advisory.htm#beaadvisorycommittee (accessed on December 2, 2009).

Rodgers, M. 2003. "A survey of economic growth." *Economic Record*. Vol. 79. No. 244. p. 112–135.

Salter, W.E.G. 1959. "Internal and external balance: The role of price and expenditure effects." *Economic Record*. Vol. 35. p. 226–238.

Silver, M., and K. Mahadavy. 1989. "The measurement of a nation's terms of trade effect and real national disposable income within a national accounting framework." *Journal of the Royal Statistical Society. Series A*. Vol. 152. No. 1. p. 87–107.

Stuvel, G. 1956. "A new approach to measurement of terms-of-trade effects." *Review of Economics & Statistics*. Vol. 38. No. 3. p. 294–307.

Swan, T.W. 1960. "Economic control in a dependent economy." *Economic Record*. Vol. 36. No. 73. p. 51–66.

Törnqvist, L. 1936. "The Bank of Finland's consumption price index." *Bank of Finland Monthly Bulletin*. No. 10. p. 1–8.

ECONOMIC ANALYSIS (EA)
RESEARCH PAPER SERIES
Catalogue 11F0027

No. 001 *A Comparison of Canada-U.S. Economic Growth in the Information Age, 1981-2000: The Importance of Investment in Information and Communication Technologies,* ***Philip Armstrong, Tarek M. Harchaoui, Chris Jackson and Faouzi Tarkhani (March 1, 2002)***

No. 002 *Purchasing Power Parity: A Canada/U.S. Exploration,* ***Beiling Yan (May 2002)***

No. 003 *The Trend to Smaller Producers in Manufacturing: A Canada/U.S. Comparison,* ***John Baldwin, Ron S. Jarmin, Jianmin Tang (May 2002)***

No. 004 *Foreign Affiliate Trade Statistics – 1999: How Goods and Services are Delivered in International Markets,* ***Balance of Payments Division, Colleen Cardillo (April 2002)***

No. 005 *Regional Manufacturing Employment Volatility in Canada: The Effects of Specialization and Trade,* ***John Baldwin and W.Mark Brown (April 11, 2003)***

No. 006 *Growth History, Knowledge Intensity and Capital Structure in Small Firms,* ***G. Gellatly, S. Thornhill, A. Riding (August 6, 2003)***

No. 007 *Accounting for Greenhouse Gases in the Standard Productivity Framework,* ***Tarek Harchaoui, Dmitry Kabrelyan and Rob Smith (November 1, 2002)***

No. 008 *Overcoming Distance, Overcoming Borders: Comparing North American Regional Trade,* ***W. Mark Brown (April 16, 2003)***

No. 009 *Assessing the Impact of Greenhouse Gas Emissions on Canada's Productivity Growth, 1981-1996: An Expermental Approach,* ***Tarek M. Harchaoui and Pierre Lasserre (November 1, 2002)***

No. 010 *A Frontier Approach to Canada-U.S. Multifactor Productivity Performance,* ***Kaïs Dachraoui, Tarek M. Harchaoui (April 3, 2003)***

No. 011 *Participation in Export Markets and Productivity Performance in Canadian Manufacturing,* ***John R. Baldwin, Wulong Gu (August 13, 2003)***

No. 012 *Impact of Advanced Technology Use on Firm Performance in the Canadian Food Processing Sector,* ***John R.Baldwin, David Sabourin and David Smith (June 3, 2003)***

No. 013 *Foreign Affiliate Trade Statistics – Canadian Operations Abroad, 1999 to 2001-* ***Balance of Payments Division, by Michael Marth (May 2003)***

No. 014 *The Effect of Tariff Reductions on Firm Size and Firm Turnover in Canadian Manufacturing,* ***Wulong Gu, G.Sawchuk, L.Whewell (August 19, 2003)***

No. 015 *The Sources of Growth of the Canadian Business Sector's CO2 Emissions, 1990-1996,* ***by Kaïs Dachraoui, Gerry Gravel, Tarek M. Harchaoui and Joe St. Lawrence (September 2003)***

No. 016 *The Impact of Self-employment on Labour Productivity Growth: A Canada and United States Comparison,* ***John R. Baldwin, James Chowhan (August 21, 2003)***

No. 017 *Public Capital and Its Contribution to the Productivity Performance of the Canadian Business Sector,* ***Tarek M. Harchaoui and Faouzi Tarkhani (November 12, 2003)***

No. 018 *Prosperity and Productivity: A Canada-Australia Comparison,* ***Tarek M. Harchaoui, Jimmy Jean and Faouzi Tarkhani (December 9, 2003)***

No. 019 *Hollowing-out, trimming-down or scaling-up? An Analysis of head Offices in Canada, 1999-2002,* ***John Baldwin, Desmond Beckstead and W. Mark Brown (December 8, 2003)***

No. 020 *The Effect of Changing Technology Use on Plant Performance in the Canadian Manufacturing Sector,* ***John Baldwin and David Sabourin (July 27, 2004)***

No. 021 *Industrial Competition, Shifts in Market Share and Productivity Growth.* ***John Baldwin and Wulong Gu (July 22, 2004)***

No. 022 *Innovation, Survival and Performance of Canadian Manufacturing Plants,* ***John Baldwin and Wulong Gu (September 2004)***

No. 023 *Renewing Canada's Manufacturing Economy: A Regional Comparison, 1973-1996,* ***W. Mark Brown (October 21, 2004)***

No. 024 *Catching Up and Falling Behind: The Performance of Provincial GDP per Capita from 1990 to 2003,* ***John R. Baldwin, W. Mark Brown, Jean-Pierre Maynard, Danielle Zietsma (November 9, 2004)***

No. 025 *Whatever Happened to Canada-U.S. Economic Growth and Productivity Performance in the Information Age?* ***Tarek M. Harchaoui and Faouzi Tarkhani (November 23, 2004)***

No. 026 *Water Use, Shadow Prices and the Canadian Business Sector Productivity Performance,* ***Kaïs Dachraoui and Tarek M. Harchaoui (December 1, 2004)***

No. 027 *Trade Liberalization: Export-market Participation, Productivity Growth and Innovation,* ***John Baldwin and Wulong Gu (December 14, 2004)***

No. 028 *A Comparison of Canadian and U.S. Productivity Levels: An Exploration of Measurement Issues,* ***John R. Baldwin, Jean-Pierre Maynard, Marc Tanguay, Fanny Wong and Beiling Yan (January 20, 2005)***

No. 029 *Integration and Co-integration: Do Canada-U.S. Manufacturing Prices Obey the 'Law of One Price'?,* ***André Bernard, Paul Warren and Beiling Yan (February 15,, 2005)***

No. 030 *Profitability of Canadian- versus U.S.-Controlled Enterprises,* ***Paul Warren (March 3, 2005)***

No. 031 *Responses to Trade Liberalization: Changes in Product Diversification in Foreign- and Domestic-Controlled Plants,* ***John R. Baldwin, Richard Caves and Wulong Gu (March 24, 2005)***

No. 032 *Canada's Investments in Science and Innovation: Is the Existing Concept of research and Development Sufficient?,* ***John R. Baldwin, Desmond Beckstead and Guy Gellatly (April 12, 2005)***

No. 033 *Death in the Industrial World: Plant Closures and Capital Retirement,* ***John R. Baldwin (May 4,, 2005)***

No. 034 *Foreign Multinationals and Head Office Employment in Canadian Manufacturing Firms,* ***John R. Baldwin and W. Mark Brown (June 8, 2005)***

No. 035 *Demand for Skills in Canada: The Role of Foreign Outsourcing and Information-Communication Technology,* ***Beiling Yan (October 28, 2005)***

No. 036 *Trade Credit and Credit Rationing in Canadian Firms,* ***Rose Cunningham (November 4, 2005)***

No. 037 *Key Indicators in Canada,* ***Paul Warren (November 30, 2005)***

No. 038 *The Impact of Trade on Plant Scale, Production-Run Length and Diversification,* ***John R. Baldwin and Wulong Gu (May 19, 2006)***

No. 039 *How are Canadian Regions Adjusting to a Larger and More Integrated North American Market?,* ***Wulong Gu and Gary D. Sawchuk (May 31, 2006)***

No. 040 *A Proposal for Treating Research and Development as Capital Expenditures in the Canadian SNA,* ***Meir Salem and Yusuf Siddiqi (June 29, 2006)***

No. 041 *Exchange Rate Cycles and Canada–U.S. Manufacturing Prices,* ***John R. Baldwin and Beiling Yan (June 28, 2006)***

No. 042 *Competition, Firm Turnover and Productivity Growth,* ***John R. Baldwin and Wulong Gu, (September 25, 2006)***

No. 043 *Domestic and Foreign Influences on Canadian Prices over Exchange Rate Cycles, 1974 to 1996,* ***John R. Baldwin and Beiling Yan, (November 8, 2006)***

No. 044 *The Ebb and Flow of Comparative Advantage: Trade and the Industrial Specialization of Canadian Manufacturing Regions, 1974 to 1999,* ***W. Mark Brown (June 25, 2007)***

No. 045 *Urban Economies and Productivity,* ***John R. Baldwin, Desmond Beckstead, W. Mark Brown and David L. Rigby (June 18, 2007)***

No. 046 *Real GDP and the Purchasing Power of Provincial Output,* ***Ryan Macdonald (July 24, 2007)***

No. 047 *Estimating TFP in the Presence of Outliers and Leverage Points: An Examination of the KLEMS Datase,* ***Ryan Macdonald (December 5, 2007)***

No. 048 *Canadian and U.S. Real Income Growth Pre and Post 2000: A Reversal of Fortunes,* ***Ryan Macdonald (November 22, 2007)***

No. 049 *Agglomeration Economies: Microdata Panel Estimates from Canadian Manufacturing,* ***John R. Baldwin, W. Mark Brown and David L. Rigby (February 5, 2008)***

No. 050 *An Examination of Public Capital's Role in Production,* ***Ryan Macdonald (April 15, 2008)***

No. 051 *Trade Liberalization and Productivity Dynamics: Evidence from Canada,* ***Alla Lileeva (May 7, 2008)***

No. 052 *Geographic Market Access and the Effects of Trade on Length of Production Run, Product Diversity and Plant Scale of Canadian Manufacturing Plants, 1974 to 1999,* ***John R. Baldwin, W. Mark Brown and Wulong Gu (May 9, 2008)***

No. 053 *Firm Turnover and Productivity Growth in the Canadian Retail Trade Sector,* ***by John R. Baldwin and Wulong Gu (December 8, 2008)***

No. 054 *Adapting to Import Competition: Effects of Low-wage Trade on Commodity Mix in Canadian Manufacturing Plants,* ***John R. Baldwin and Alla Lileeva (May 16, 2008)***

No. 055 *Outsourcing and Offshoring in Canada: Trends, Causes and Economic Impact,* ***John R. Baldwin and Wulong Gu (May 23, 2008)***

No. 056 *Plant Divestitures and Acquisitions in the Canadian Manufacturing Sector,* ***John R. Baldwin, Robert Gibson and Yanling Wang (June 4, 2009)***

No. 057 *The Canadian Manufacturing Sector: Adapting to Challenges,* ***John R. Baldwin and Ryan Macdonald (July 2009)***

No. 058 *PPPs: Purchasing Power or Producing Power Parities?,* ***by John Baldwin and Ryan Macdonald (December 2009)***